LA-UR-18-24283
Approved for public release; distribution is unlimited.

Title: Using Discrete Fracture Network Model in Understanding LTDE-SD Field Experiment

Author(s): Makedonska, Nataliia
Viswanathan, Hari S.
Karra, Satish

Intended for: Annual meeting on Spent Fuel and Waste Science Technologies, 2018-05-22/2018-05-24 (Las Vegas, Nevada, United States)

Issued: 2019-10-07 (rev.1)

Spent Fuel and Waste Science and Technology

Using Discrete Fracture Network Model in Understanding LTDE-SD Field Experiment

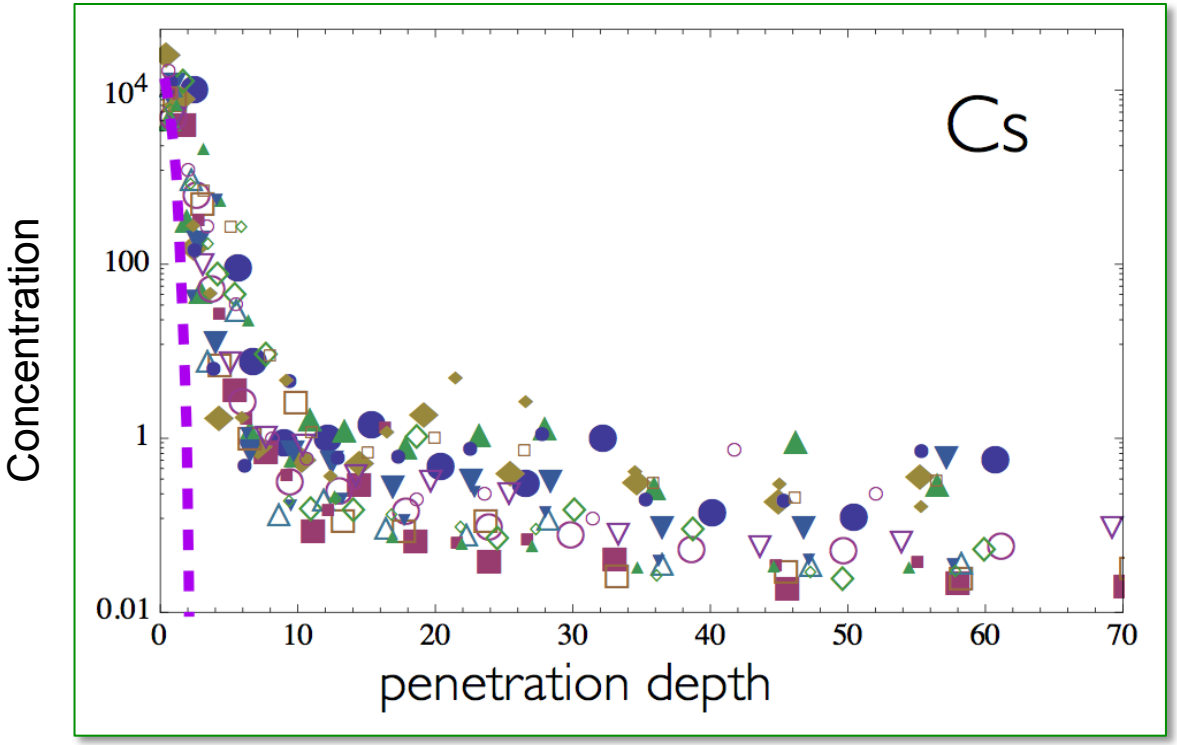
Hari S. Viswanathan, Nataliia Makedonska, Satish Karra
Computational Earth Science Group
Los Alamos National Laboratory

SFWST Annual Working Group Meeting
Las Vegas, Nevada
May 22-24, 2018

Acknowledgment: For Sandia, it will be the SAND number and the NTESS funding statement, for other labs it will be whatever is required by their system.

Motivation

Penetration Profile in Long-Term Diffusion Experiment



LANL Modeling Approach:

Include micro-structure directly into a high fidelity simulation using discrete fracture network model. Tracer penetrates into the solid continuum sample core through micro-fractured damage zone.

Fracture Network Generation

- *Domain size is 5cm × 5cm × 5cm; total volume 125 cm^3.*
- *All fractures size follow Power Law distribution, where smallest fracture length is 1 mm and longest fracture length is 10 mm.*
- *All fractures in the DFN are connected and provide a connected path through fractures for transport.*

DFN input parameters
(Äspö characteristics for the fracture data)

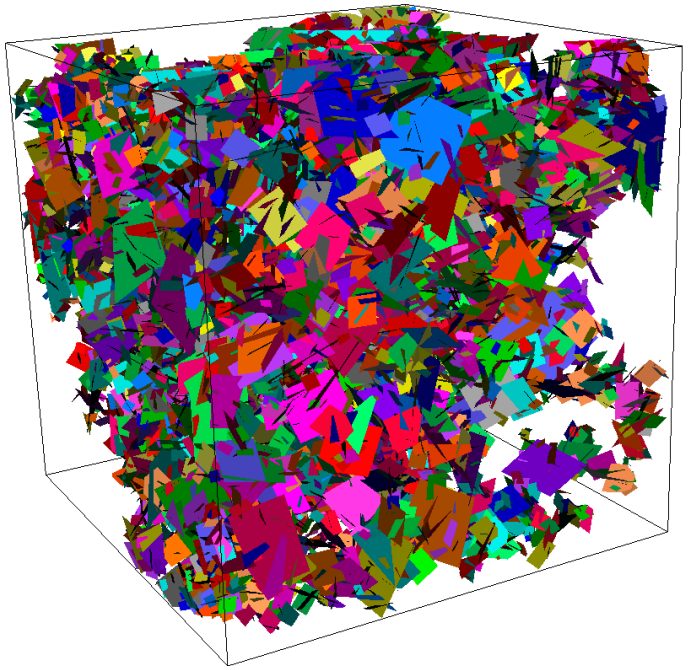
Set	Trend	Plunge	Kappa	R_{Min}	R_{Max}	Alpha	P_{32}
1	280	20	10	0.0005	0.005	2.6	750
2	20	10	15	0.0005	0.005	2.6	1000
3	120	50	10	0.0005	0.005	2.6	500

Fracture Intensity is varied in vertical direction to generate different DFN configurations of a sample, which is:

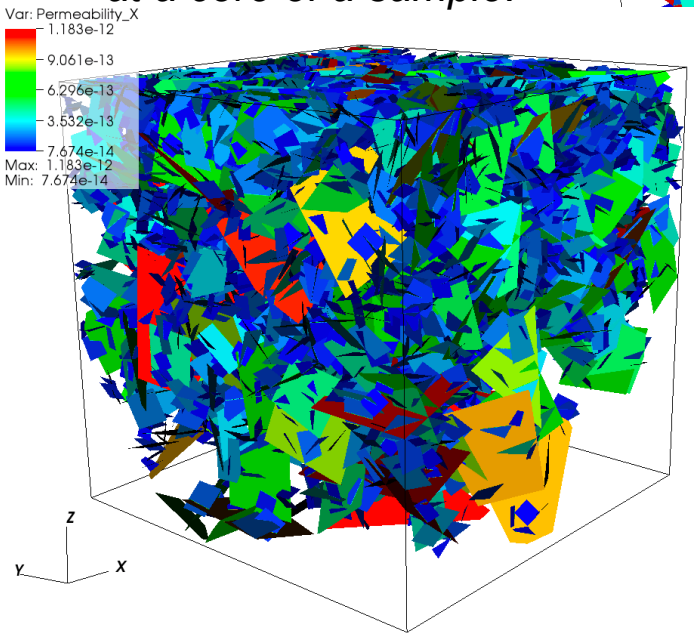
1. ***Micro-fractured originally***
2. ***Deformed at a surface and micro-fractured originally***
3. ***Deformed at a surface and kept solid at a core***

Three DFN Configurations:

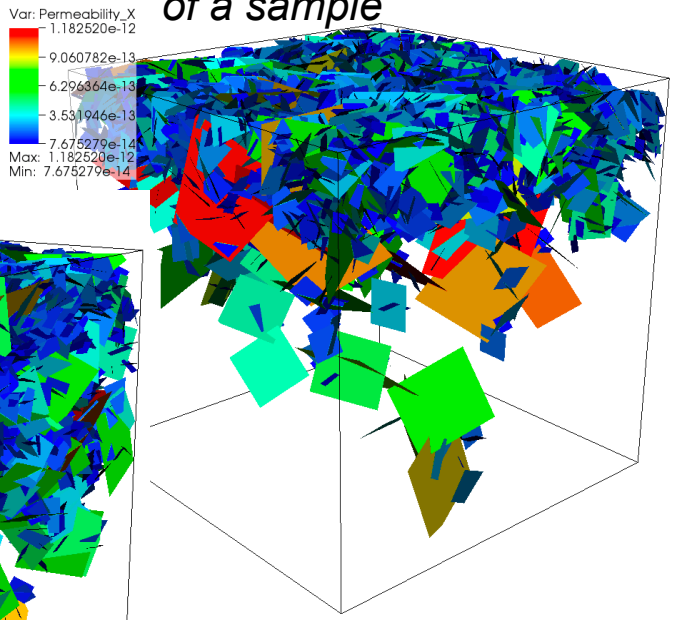
1. *DFN of high uniform micro-fracture intensity*



2. *DFN of high micro-fracture intensity at a surface of a sample (top) and decreased P_{32} at a core of a sample.*



3. *DFN of significantly low intensity at a core of a sample*

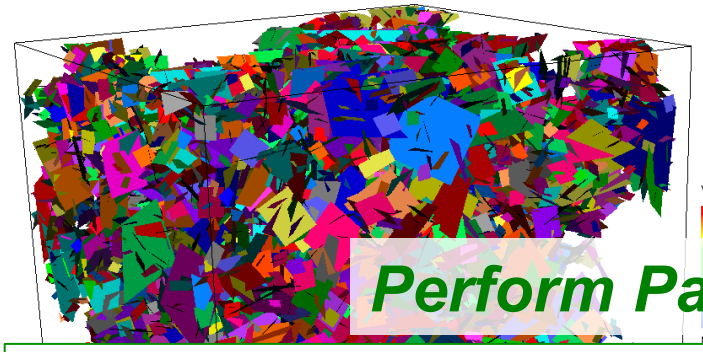


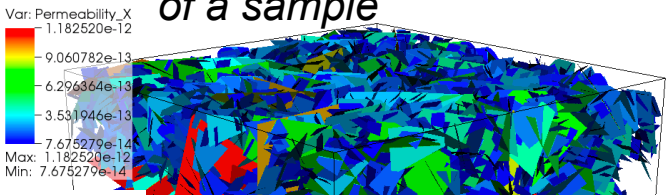
Three DFN Configurations:

1. *DFN of high uniform micro-fracture intensity*

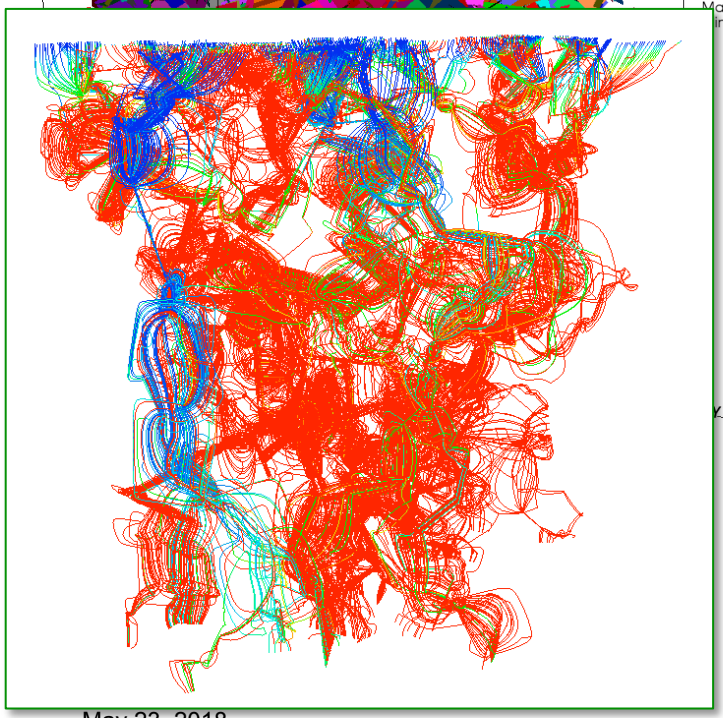
2. *DFN of high micro-fracture intensity at a surface of a sample (top) and decreased P_{32} at a core of a sample.*

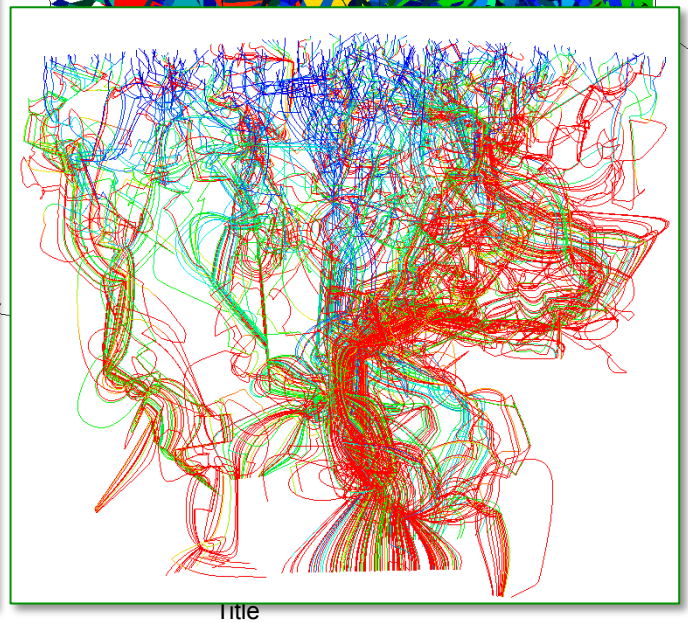
3. *DFN of significantly low intensity at a core of a sample*

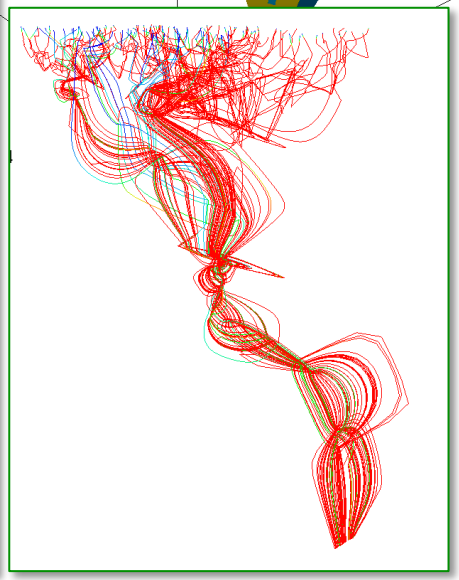




Perform Particle Tracking Simulations







Time Domain Random Walk (TDRW)

$$T = T_{adv} + \left[\frac{\frac{\phi \sqrt{D_e}}{b} T_{adv}}{erfc^{-1}(r)} \right]^2$$

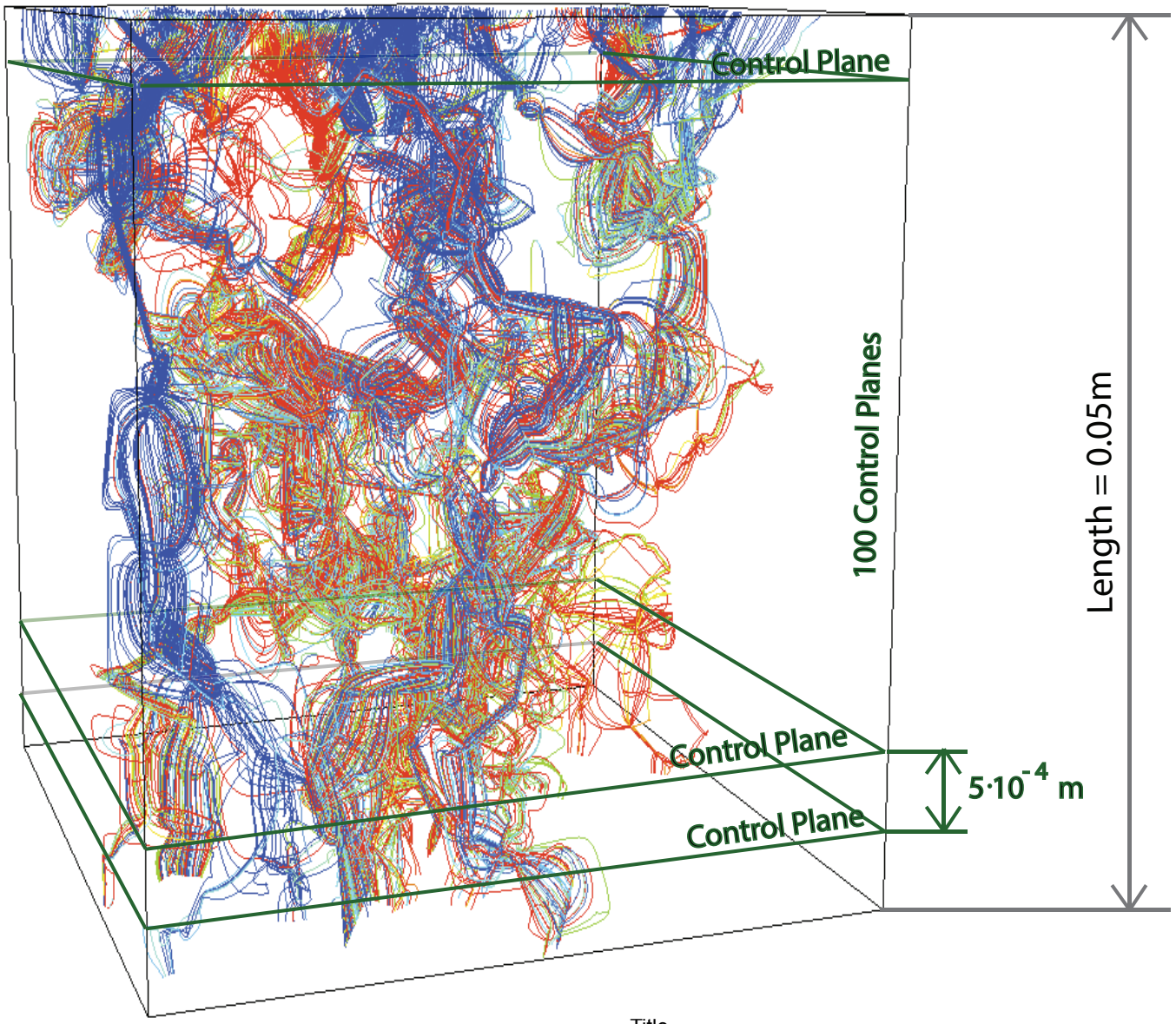
ϕ - matrix porosity, ϕ=0.001
D_e - diffusion coefficient [m^2/s]
b - fracture aperture, b(R) [m]
r - random number (0,1)

Travel Time = Time $_{Advection}$ + Time $_{Diffusion}$

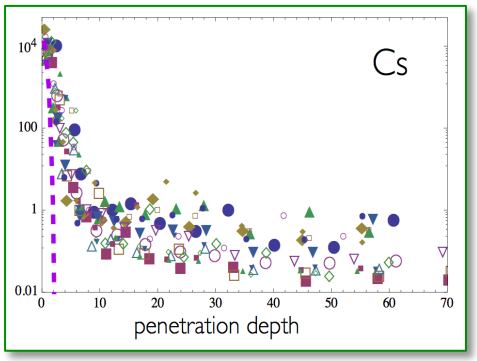
Minimize Advection: *Decrease Pressure Gradient (1 Pa)*

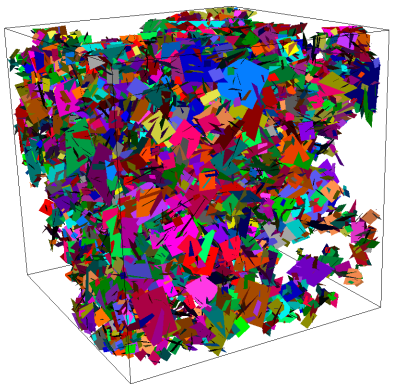
Emphasize Diffusion: *Increase Diffusion Coefficient (up to 10^{-2} m^2/s)*

Generate Penetration Profile

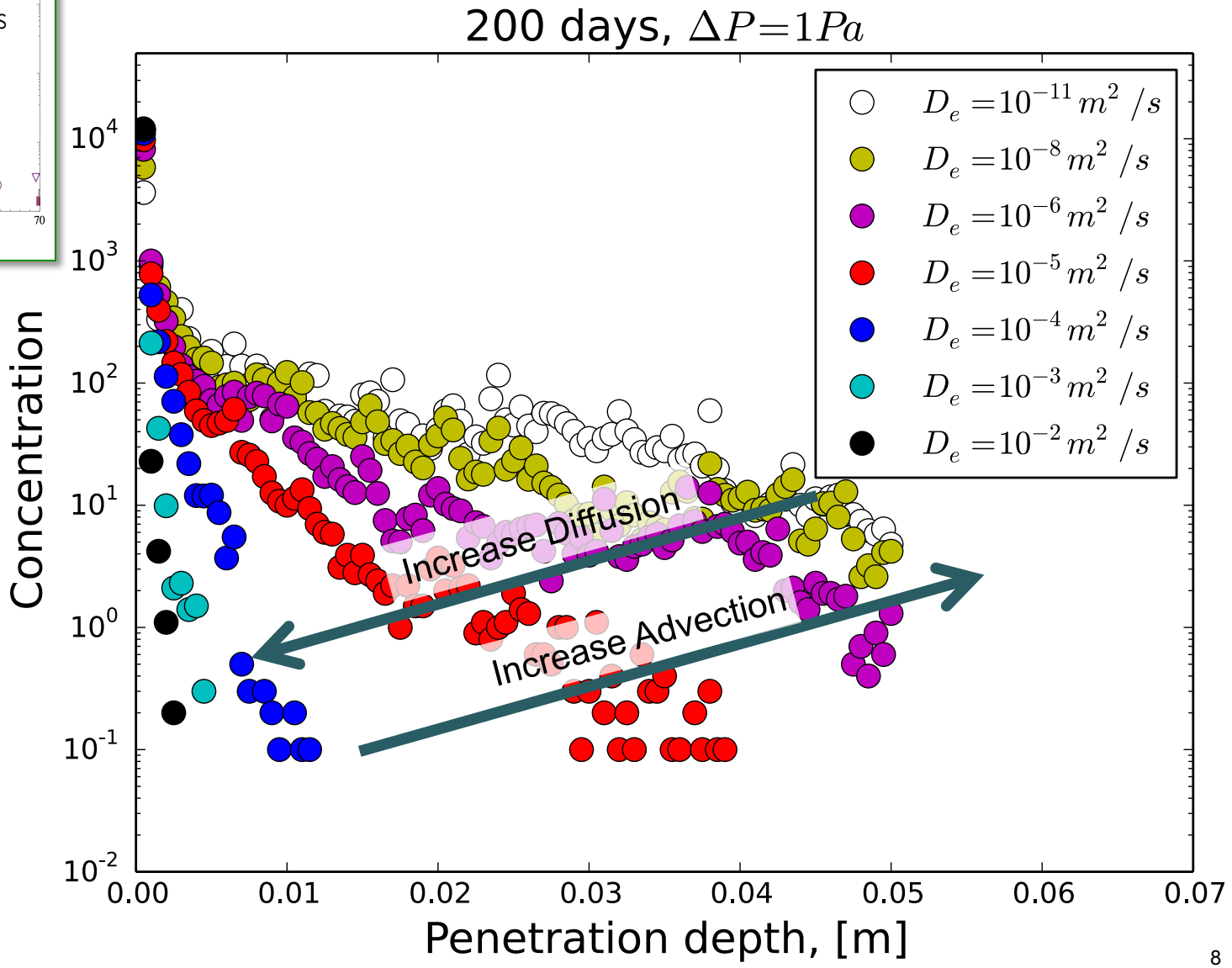


DFN Configuration 1

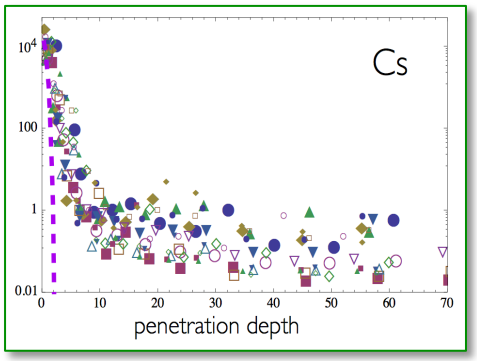


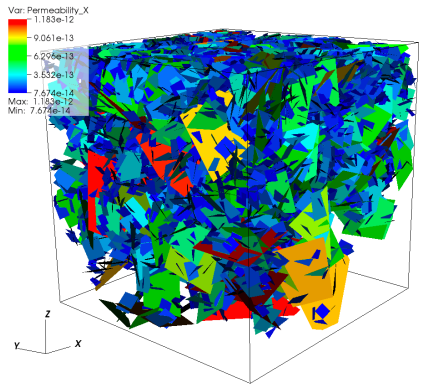


Sample is originally micro-fractured

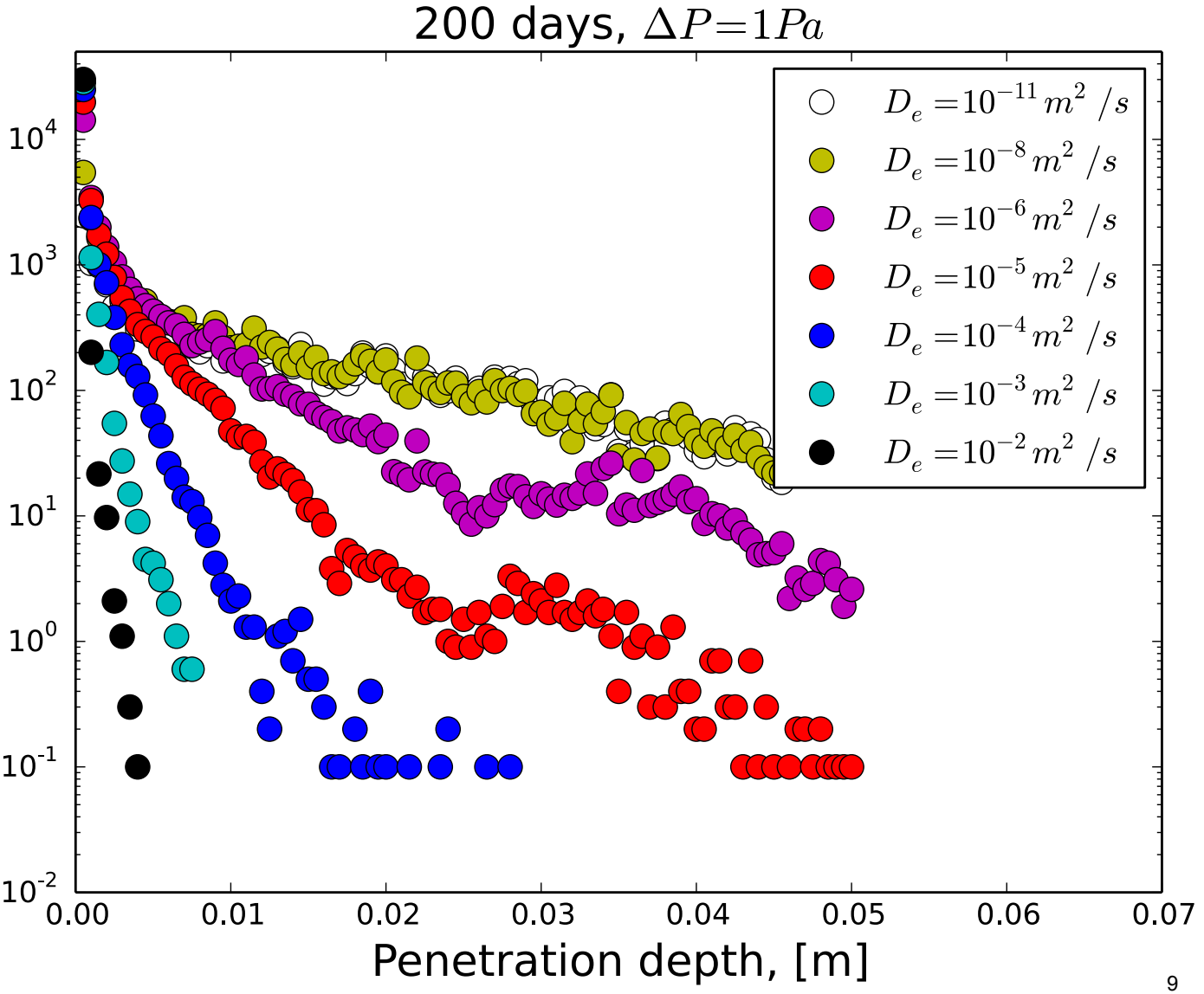


DFN Configuration 2

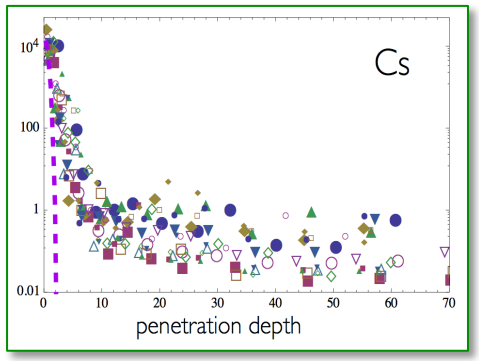


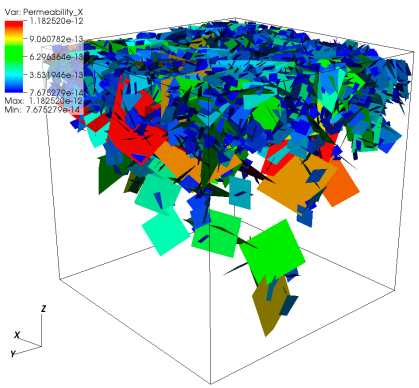


Sample is micro-fractured originally and deformed at a surface



DFN Configuration 3





No original micro-fractures, deformation at a surface

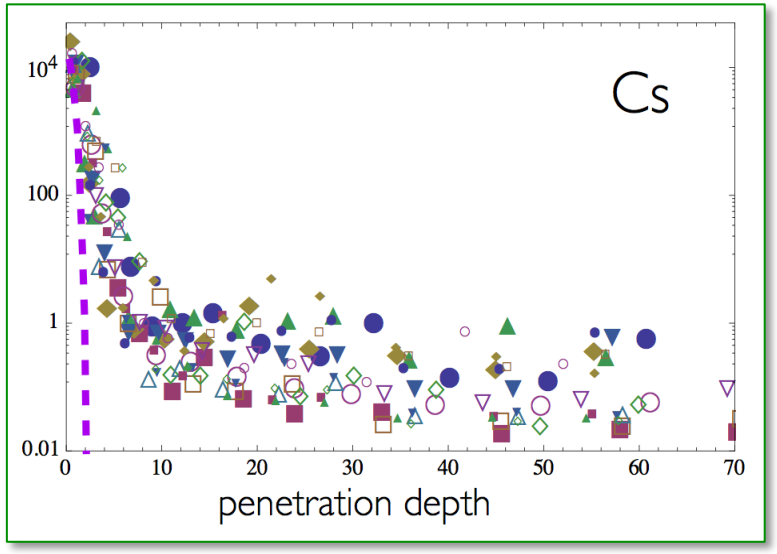
200 days, $\Delta P = 1Pa$

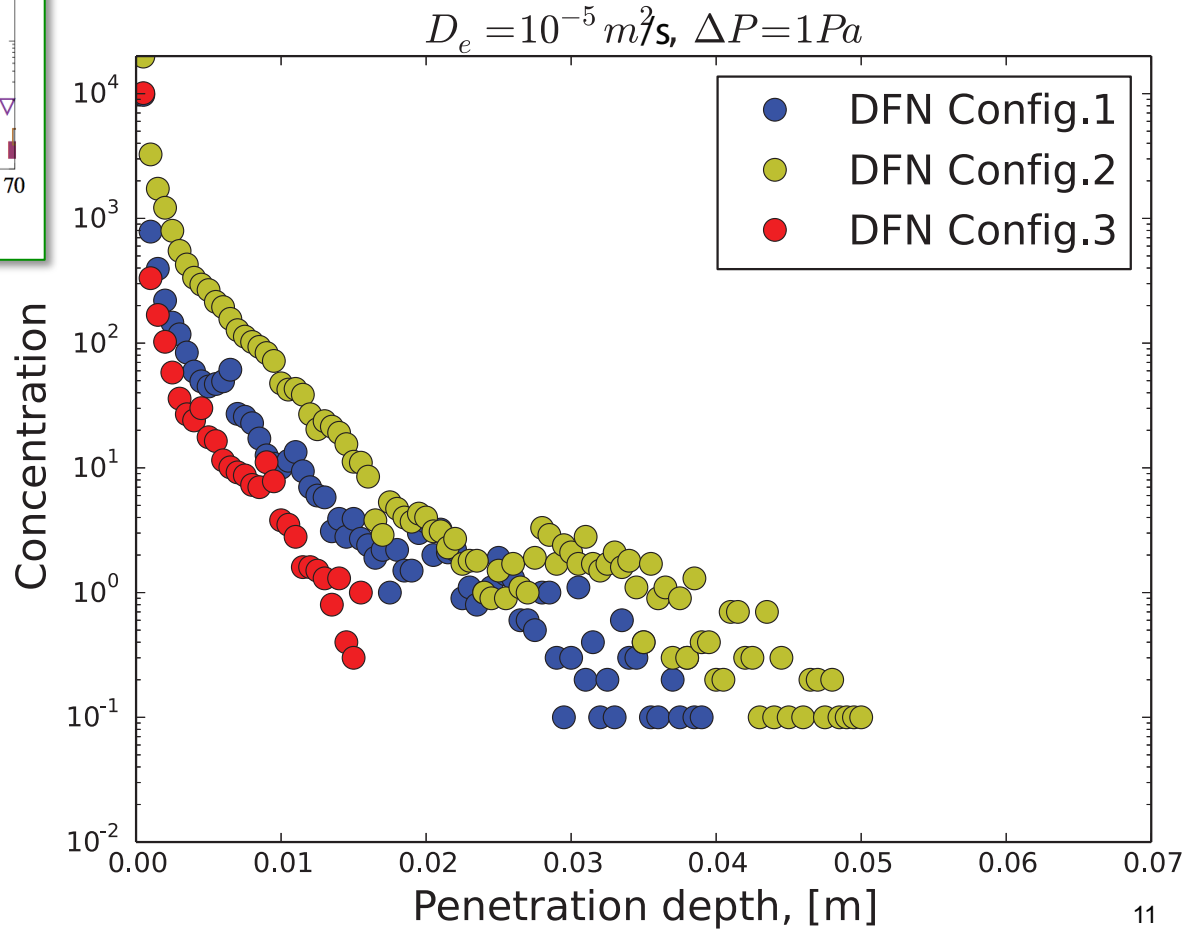
Concentration

Penetration depth, [m]

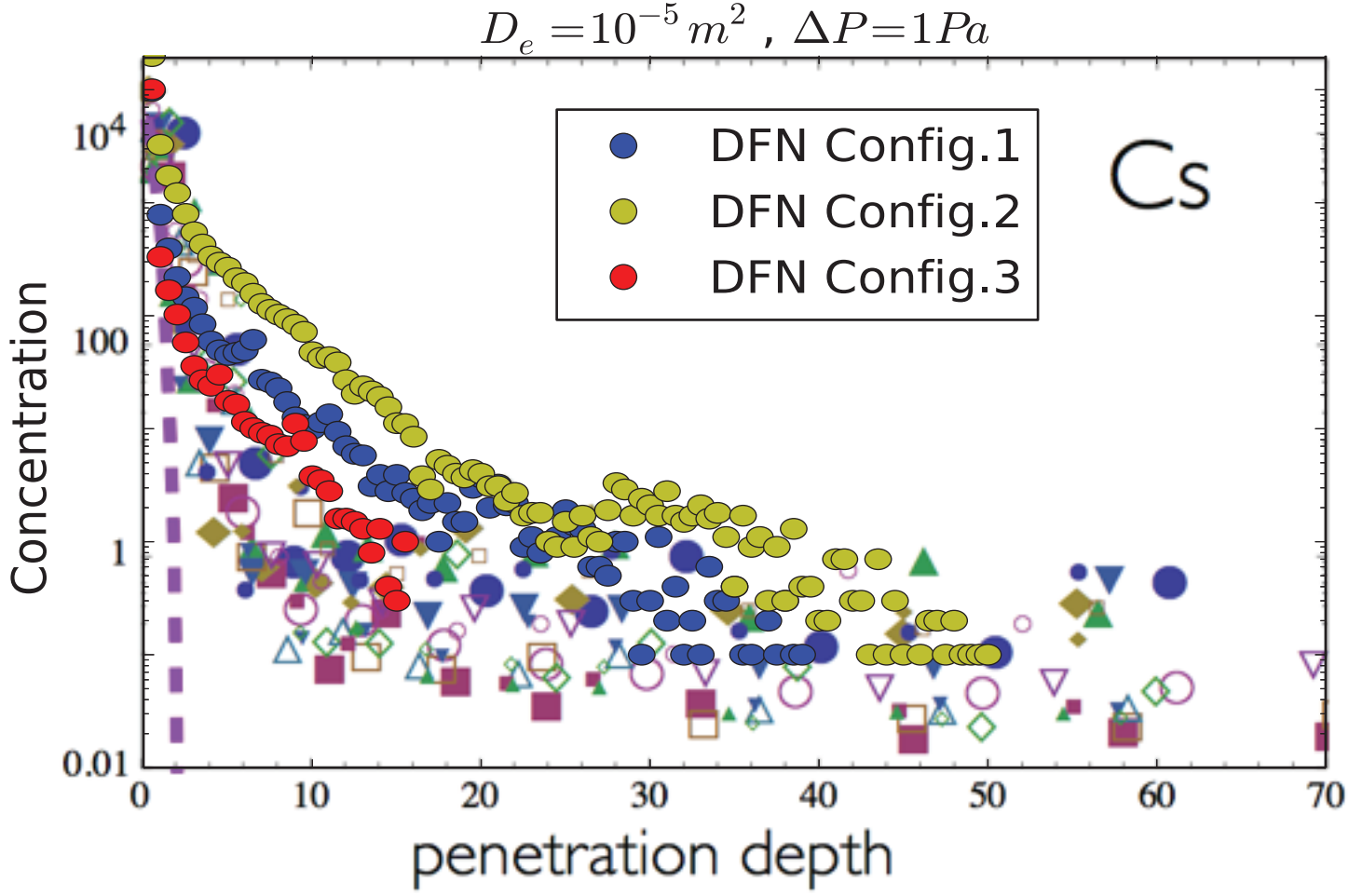
$D_e = 10^{-11}\, m^2/s$
$D_e = 10^{-8}\, m^2/s$
$D_e = 10^{-6}\, m^2/s$
$D_e = 10^{-5}\, m^2/s$
$D_e = 10^{-4}\, m^2/s$
$D_e = 10^{-3}\, m^2/s$
$D_e = 10^{-2}\, m^2/s$

Comparison with LTDE

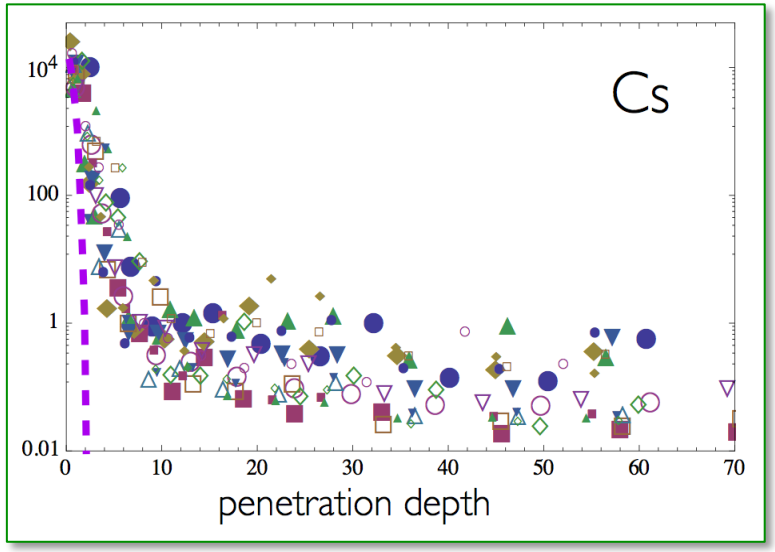


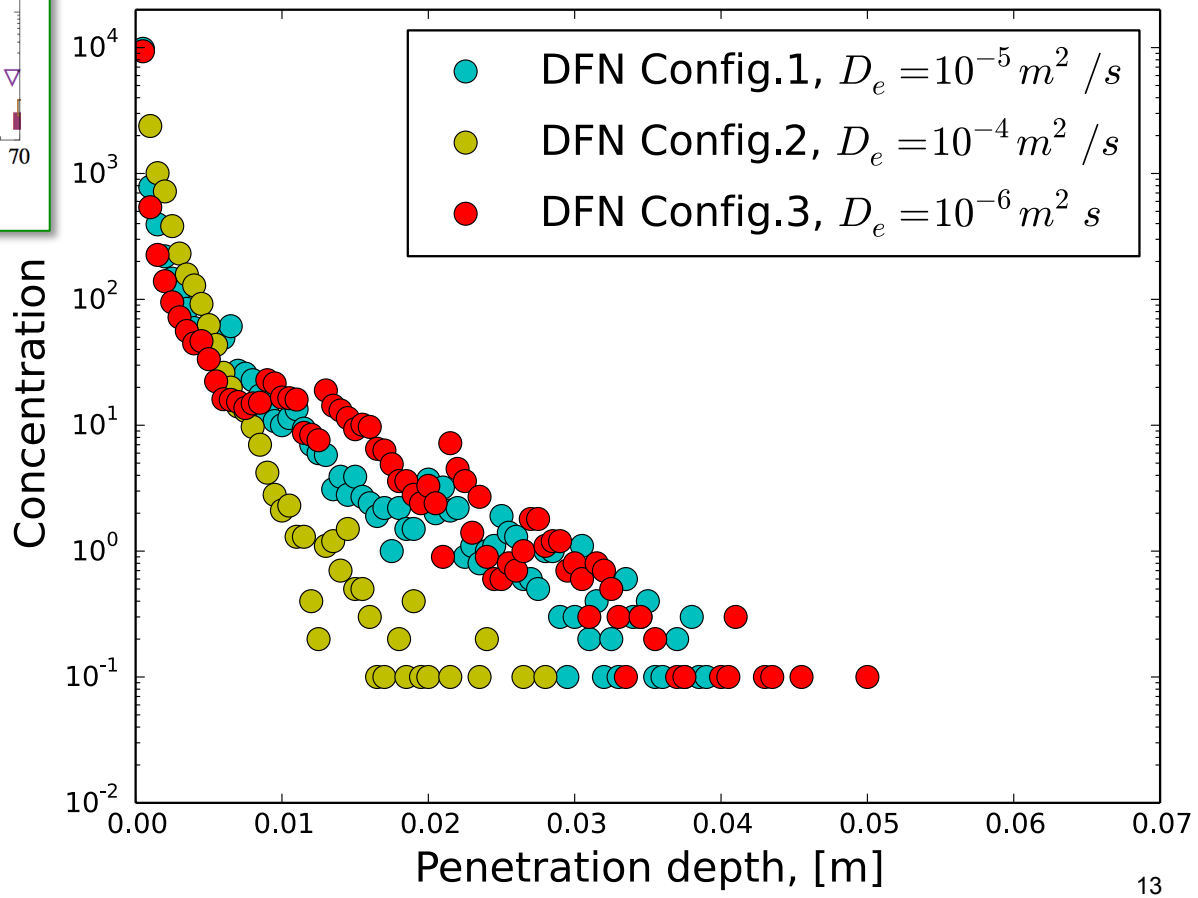


Comparison with LTDE

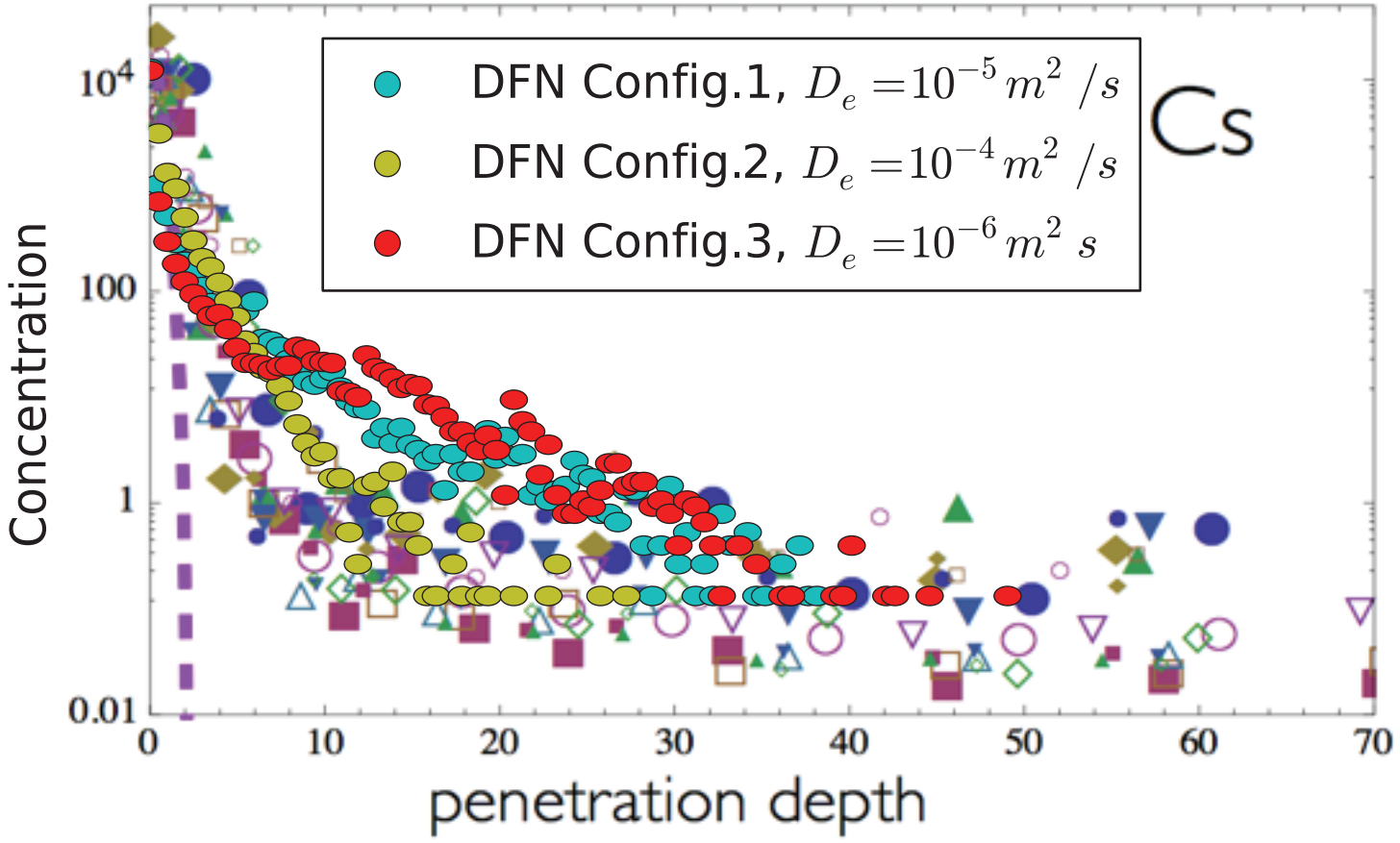


Comparison with LTDE





Comparison with LTDE



Conclusion

- Micro fractures play an important role in tracer movement through the sample
- Including advection into transport simulations helps to achieve better fit to the experimental penetration profile

Questions?